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ICTS MONTHLY COLLOQUIUM

# Morphing without Muscles:

## Hydraulic Actuation in nature

Programming motion in soft, deformable structures remains a central challenge for conventional design frameworks. Biological systems provide instructive examples of hydraulically driven morphogenesis and actuation. In holometabolous insects, for instance, *Drosophila* wings undergo rapid post-eclosion wing expansion, completed within minutes through hydraulic pressurization. I will present a minimal mechanical model that captures the essential features of this pressure-driven deployment at the organ scale. In parallel, I will discuss hydraulic actuation in *Mimosa pudica*, where localized water exchange between cells and adjacent air cavities generates fast motion. These case studies highlight how plants and insects harness geometry, compartmentalization, and fluid redistribution to achieve rapid and robust shape change, offering guiding principles for the design of hydraulically actuated soft robotic systems.



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Joel Marthelot is a researcher at the French National Center for Scientific Research (CNRS), based at Aix-Marseille University. He received his Ph.D. from ESPCI Paris, was a Raman-Charpak Fellow at TIFR Hyderabad, and subsequently held postdoctoral positions at the Massachusetts Institute of Technology and Princeton University. Since joining CNRS in 2019, his research has focused on soft actuation in living and synthetic systems, integrating fundamental studies of plant and insect biomechanics with efforts to translate these insights into engineering design.

3:30 PM IST, 04 November 2025

Zoom link: <https://shorturl.at/rEuea>

Meeting ID: 997 6856 8995

Passcode: 040506

Ramanujan Lecture Hall,  
ICTS, Bengaluru

